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# Overseas Shipping Tests of California Citrus on Pallets and in Containers -- Interrelations Between Transit Temperatures, Biphenyl Pad Placement, Biphenyl Content, and Fruit Condition

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# Overseas Shipping Tests of California Citrus on Pallets and in Containers -- Interrelations Between Transit Temperatures, Biphenyl Pad Placement, Biphenyl Content, and Fruit Condition

G. L. Rygg, *investigations leader, Market Quality Research Division, Agricultural Research Service*

## SUMMARY

study was conducted on the biphenyl residue and condition of citrus fruit shipped to Europe on ets, in cargo containers, and by break-bulk method. ulations in the European Economic Community C) permit 70 parts per million biphenyl in citrus ts. Fruit shipped into EEC areas, using biphenyl to rd spoilage, must not absorb more biphenyl than this rance.

Three test shipments of Valencia oranges and two test ments of lemons were sent to Rotterdam, Holland, 1968. The oranges were shipped in mechanically igerated railcars to Saint John, N.B., for transit to terdam in refrigerated ships. The lemons were sent in igerated cargo containers by rail to New York, where containers were transferred to a ship bound for terdam. Two of the orange shipments were pre- led and one was nonprecooled.

Transit temperatures of the oranges averaged from ° to 48.7° F., about the same as the average of mptly loaded test shipments sent in ice-refrigerated in 1967. The transit temperatures of the 1968 nge shipments were more uniform than those of the 7 shipments. The temperatures of one of the cooled shipments were no lower than those of the precooled shipment.

Only one experimental sample of oranges contained e biphenyl on arrival than the EEC tolerance of 70 m., and this was only slightly higher. One week after val more than one-half of the samples contained re than 70 p.p.m., and after 2 weeks from 75 to 90 cent exceeded 70 p.p.m. Only 6 percent of the ples contained more than 110 p.p.m. biphenyl 2 ks after arrival. Precooling did not reduce the biphenyl residue or the decay and soilage. Highest biphenyl residues occurred in cartons with the pads placed at the middle and bottom, and in those with pads between layers. Lowest residues occurred in cartons with one pad at the middle of the carton, but this fruit also had more decay and soilage. Top and bottom placement gave the lowest residue without excessive sacrifice in control of decay and soilage.

Palletizing did not affect biphenyl residue. Oranges on pallets had less decay and soilage than break-bulk fruit after 2 weeks' holding, but differences were not consistent at the earlier inspections.

Spoilage and biphenyl content increased rapidly during 2 weeks' nonrefrigerated holding in Holland.

Biphenyl pads in orange cartons retained about one-half to two-thirds of their initial biphenyl content on arrival. The biphenyl was halved 1 week after arrival and halved again 2 weeks after arrival.

The temperature of the lemons in the cargo containers was fairly uniform during transit. Palletized lemons had an average transit temperature of 57.5° F., and break-bulk lemons 57.1°. The biphenyl content of these lemons on arrival was 18 and 20 p.p.m., respectively. The residue in both increased to 25 p.p.m. during 2 weeks' holding at 72° to 75°.

Decay and soilage were less than 4 percent each on arrival. They did not increase appreciably until the second week after arrival, and then only in the break-bulk fruit.

Biphenyl pads in lemon cartons retained about the same proportion of the initial biphenyl as those in orange cartons on arrival and after 2 weeks' holding.

## INTRODUCTION

Recent developments in facilities used to transport California citrus fruits to the European markets include pallets, mechanically refrigerated railcars, and cargo containers. Little or no experimental data are available on the residue of the volatile fungistat biphenyl and the condition of fruit handled in these facilities. This information was needed because of the 70 p.p.m. biphenyl tolerance of the European Economic Community (EEC).

To secure such information, three test shipments of Valencia oranges were sent to Rotterdam, Holland, using different sizes of pallets for two shipments and the break-bulk method for the other. Two test shipments of lemons in cargo containers also were sent to Rotterdam. All these shipments crossed the continent on rails to the Atlantic seaboard and were carried by refrigerated ships to Rotterdam. The transit period was 21 or 22 days for the oranges and 19 days for the lemons.

Fruit on pallets receives more gentle handling than fruit moved in individual cartons. Fruit in containers receives the most gentle treatment of all in overseas shipments, as the cartons are not moved individually between packinghouse and destination. Unloading may take place at or near the harbor, or at some interior market area. Transportation in containers also has the advantage of providing nearly continuous refrigeration, as the containers have built-in refrigerating units.

## PROCEDURE

### Oranges

Three orange test shipments were sent from southern California to Rotterdam at weekly intervals. In each shipment oranges packed in 4/5-bushel vented fiberboard cartons were loaded into mechanically refrigerated railcars with the thermostats set at 42° F. Three methods of stowing were used—break-bulk, on 34- by 34-inch pallets, and on 41- by 47-inch pallets. A recording thermometer was placed near the center of each of two cartons in each kind of stow.

Four patterns of placement of the biphenyl pads in the cartons were tested in triplicate. The placements were (1) top and bottom; (2) middle and bottom; (3) between layers, or one pad above the bottom layer of fruit and one under the top layer of fruit; and (4) 1 pad in the middle, above the third layer of fruit. Of the three similar cartons, one was sampled soon after arrival, the second 1 week after the first, and the third carton 2 weeks after the first. These pad placements were tested in each break-bulk and palletized lot of oranges. The pads in the package used in these tests contained an average of 2,140 milligrams biphenyl at the beginning of the tests.

The orange and lemon cartons used in these tests measured 16-3/8 by 10-1/16 inches. The pallets differed slightly from the standard sizes—they were 34 by 34 inches, 41 by 47 inches, and 35 by 42 inches. These dimensions allowed for slight bulging of the cartons.

The cartons in the break-bulk portion of the loads were placed in a registered chimney pattern (fig. 1A). The cartons on the 34- by 34-inch pallets were placed in a registered solid pattern (fig. 1B). The cartons on the 41- by 47-inch pallets were placed in a registered pattern with two chimneys (fig. 1C). Cartons stowed in a registered pattern are placed directly above the ones below. The test packages were in the second, third, fourth, and fifth layers.

The cartons were secured on pallets by placing adhesive filament tape across the pallets over the fourth and sixth layers with three tapes in each direction. Elastic ties consisting of heavy twine and heavy rubber bands were placed around each pallet load at the third and sixth layers. The disposable pallets were of inexpensive wood.

The oranges in the first test shipment were loaded without precooling at an average temperature of 73° F. The second and third shipments were precooled nearly 3 days, from Friday afternoon until the following Monday morning, in rooms with thermostats set at 42° . Loading temperature of this fruit ranged from 47° to 59° . The slow and irregular cooling suggests that the cooling capacity was inadequate or the air distribution needed improvement.

Upon transfer of the fruit to the ships at Saint John, N.B., two layers of break-bulk cartons were stowed above the palletized portion of the load, and the remainder of each load was stowed eight cartons deep. The test cartons were again placed in the second to fifth layers.

Considerable difficulty was experienced in transferring the orange pallets from the railcars to the ships' holds at Saint John, especially the larger pallets. The weakness of the wood in these pallets was the main reason for the difficulty, but the weak floor racks in the ships' holds were also a contributing factor. It is

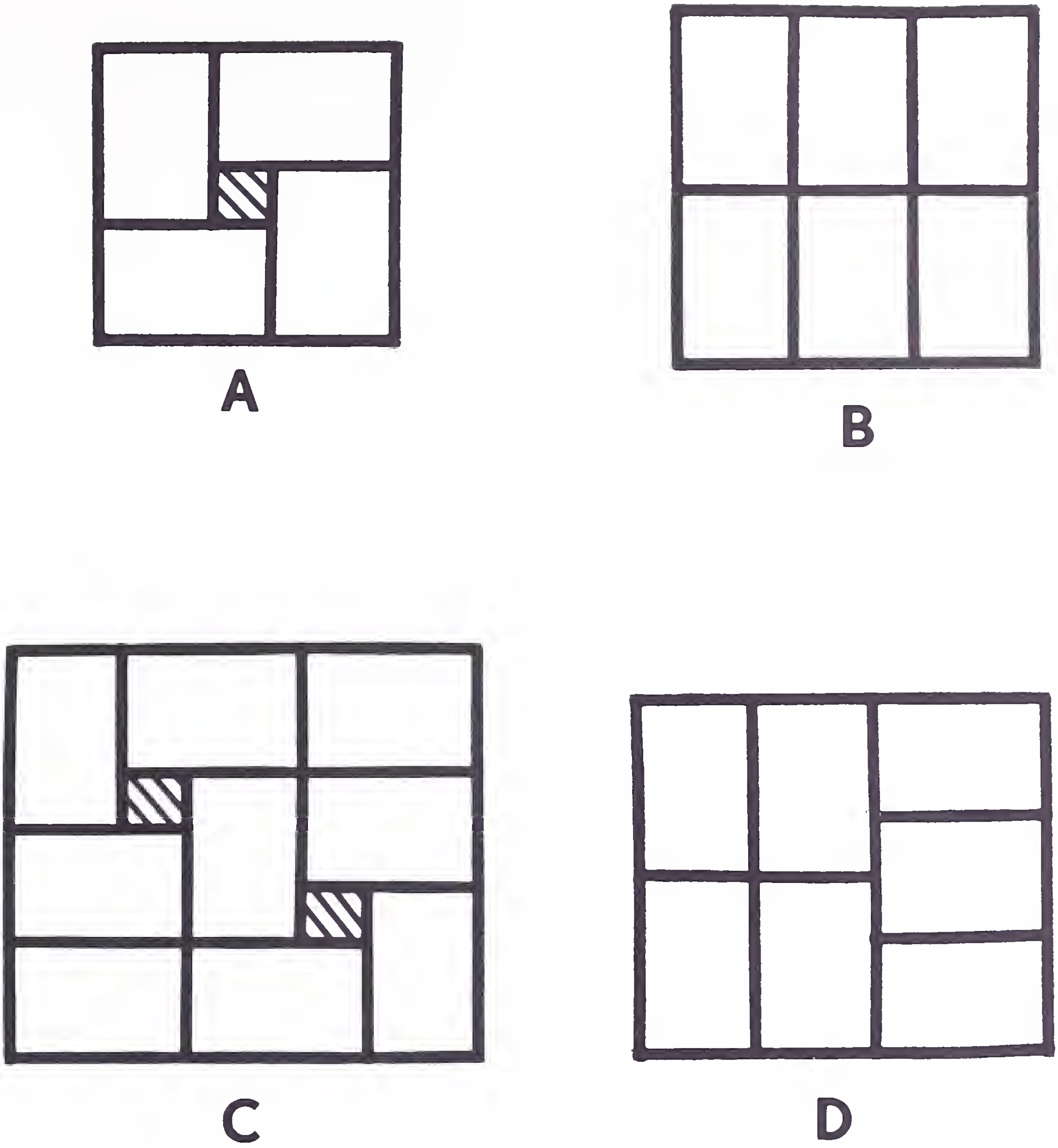

*Figure 1.*—Loading patterns: A. Chimney pattern was used in break-bulk stowing of oranges and lemons. B. Oranges on 34- by 34-inch pallets were stowed in this pattern. C. Oranges on 41- by 47-inch pallets were stowed in this pattern with 2 chimneys. D. Lemons on 35- by 42-inch pallets were stowed in this pattern.

recommended that these floor racks be removed from the holds in which pallets are to be stowed. The pallets themselves provide adequate air passages under the load of fruit.

Pallet loads were difficult to unload from the ships at destination. Some of the test cartons were removed from the pallets soon after the pallets were unloaded from the ships, and were handled as individual cartons thereafter. Others were removed while the pallets were still in the holds, as the loaded pallet could not be removed from the ship. All the cartons on such pallets were unloaded from the ships in the manner customary for break-bulk shipments.

At the earliest convenience, within 1 or 2 days, all the break-bulk and palletized test cartons were trucked to the Central Institute for Nutrition and Food Research TNO, Zeist, Holland, for holding and analysis.

The contents of one carton of each test lot were examined soon after arrival at the laboratory. Decayed and soiled fruits were counted and the decayed fruits discarded. Twenty fruits were chosen by random numbers for biphenyl analysis.

The remaining two cartons in each lot were held without refrigeration at an ambient temperature that ranged from 70.5° to 79.0° F. for 1 and 2 weeks, respectively, and then examined and analyzed in the manner described.

Biphenyl residue was analyzed by thin-layer cleanup and spectrophotometric measurements.[1]

### Lemons

The cartons in one of the two lemon loads were stowed break-bulk in a 40-foot cargo container in a registered chimney pattern (fig. 1A). The cartons in the second load were stowed in a similar container on 35- by 42-inch pallets in the registered pattern shown in figure 1D. These containers were equipped with self-contained refrigeration units, which were put into operation immediately upon completion of loading. Each carton was vented with eighteen 1-inch perforations.

Biphenyl pads from the same package as those used in the orange tests were placed at the top and bottom of the fruit of each test carton in the customary commercial manner. The test cartons were placed in the fourth layer. The greater part of each load was six layers deep, but a part near the door in each load was five layers deep. Each load consisted of 1,000 cartons.

The lemons were loaded at a temperature range of 62° to 65° F. The thermostats on the refrigerating units were set at 50° .

The containers were hauled by rail to New York, where they were transferred to a ship and carried to Rotterdam. They were then lifted from the ship and unloaded at the consignee's warehouse. There, the test packages were recovered and trucked to the laboratory of the Central Institute for Nutrition and Food Research TNO at Zeist, where they were examined and analyzed in the manner described for the oranges. The lemons were held at 72° to 75° F.

## RESULTS AND DISCUSSION

### Oranges

Temperatures

The average temperatures from packing to arrival at destination were about equal to the average of the promptly loaded test shipments sent in ice-refrigerated cars in 1967.[2] The temperatures of the 1968 shipments, however, varied less than most of those observed in 1967, mainly because of the lower railcar temperatures in 1968. The average temperatures of the 1968 shipments from packing to unloading were 48.6° , 46.0° , and 48.7° F. for the three shipments.

The temperature of the fruit in all three test lots in the first shipment (nonprecooled) and two of the three in the third shipment (precooled) reached 50° F. by the end of the fourth day after packing (fifth day of the test). All the recorded temperatures in the second shipment (precooled) reached 50° by the end of the second day after packing (third day of the test; fig. 2 to 4). All the recorded temperatures in tests 0-1 (nonprecooled) and 0-2 (precooled) reached 45° by the end of the eighth day of the test. Two of the three recorded temperatures in test 0-3 (precooled) reached 45° by the end of the seventh day of the test, but the third reading (large pallet) did not drop to 45° until the end of the 21st day, long after the fruit had been transferred to the ship. These figures do not show any consistent temperature benefit from precooling because of the slow cooling in the precooling rooms, especially in test 0-3.

The transit temperature of the part of the load in the same end of the car as the cooling unit (A-end) was usually several degrees lower than the temperature in the far end (B-end) in all three tests. The 41- by 47-inch pallets were in the A-end in the first and second tests, and the 34- by 34-inch pallets were in the B-end. The pallet positions were reversed in the third test. The break-bulk cartons were near the doorway, midway of the car, in all the shipments.

The temperatures rose from 1.5 to 4.0 degrees in the first test shipment, from 4.0 to 11.0 degrees in the second, and from 0 to 7.0 degrees in the third during the transfer from the railcars to the ships at Saint John, N.B.

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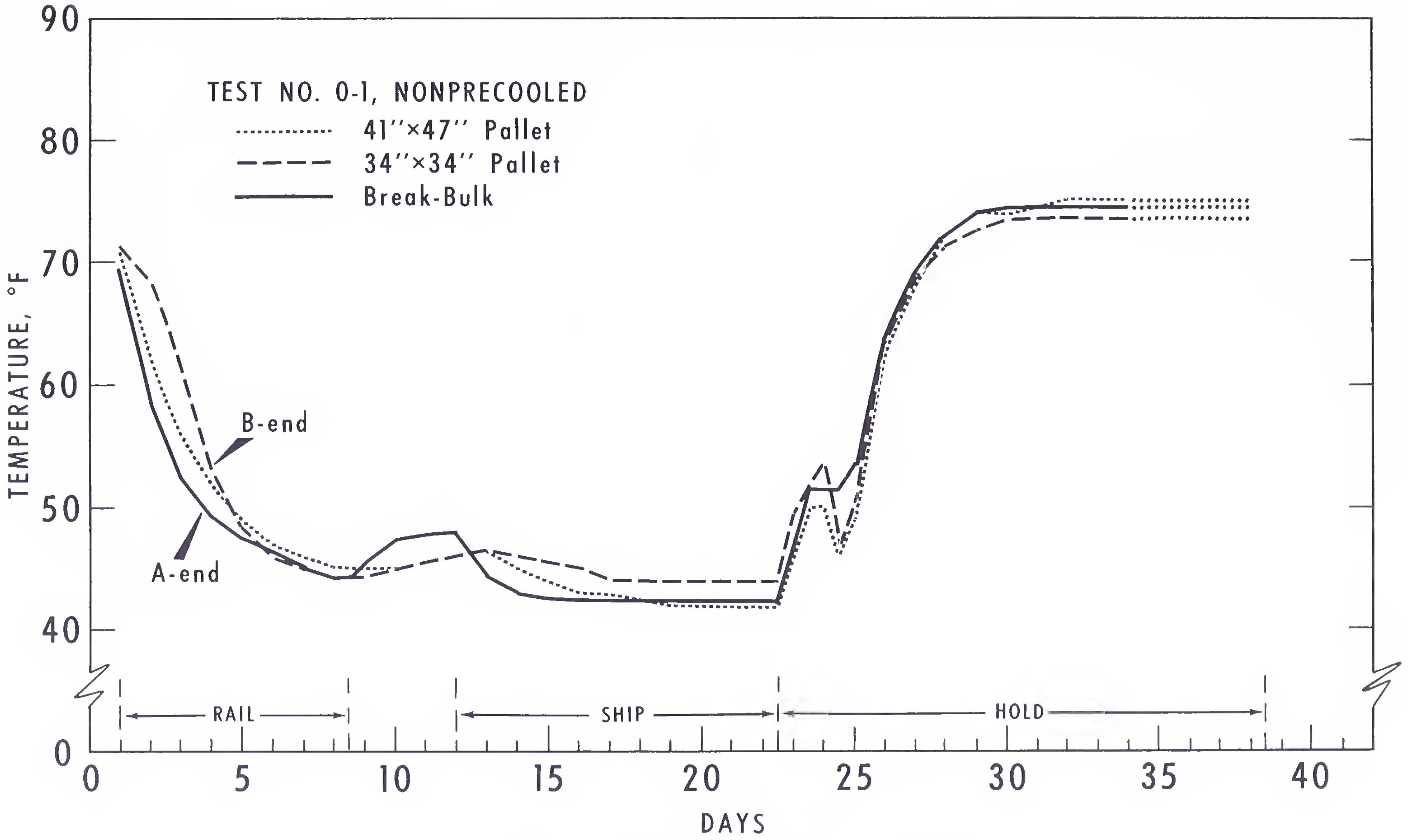
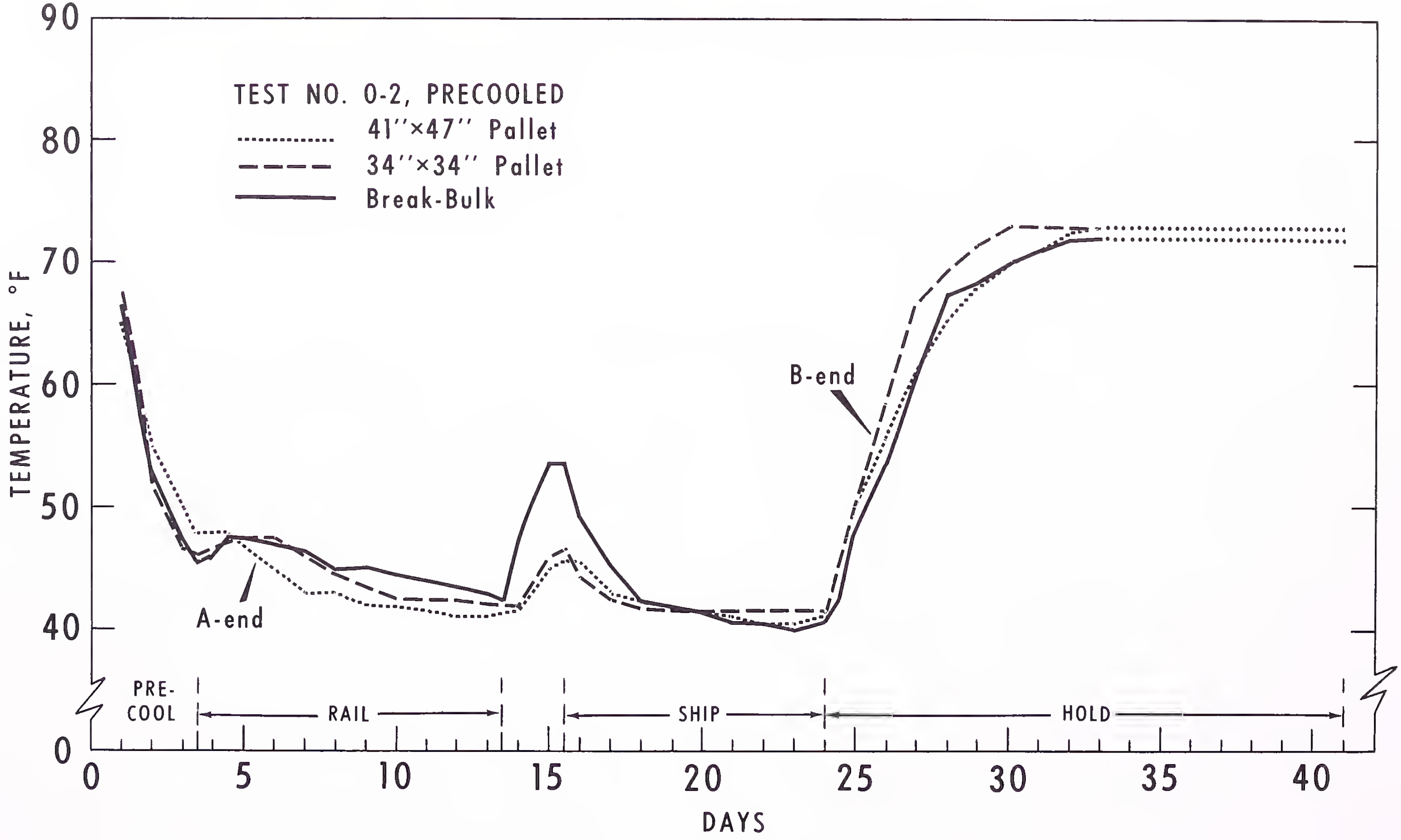
[1] *Vos, R. H. de. Analyses for the Fresh Fruit Diphenyl Project.* Central Institute for Nutrition and Food Research TNO. Rapport Nr. 2755, 15 pp. 1968.

[2] *Rygg, G. L. Biphenyl Content, Transit Temperatures, and Fruit Condition of California Citrus in Overseas Shipments.* U. S. Dept. Agr. Mktg. Res. Rpt. (in press)



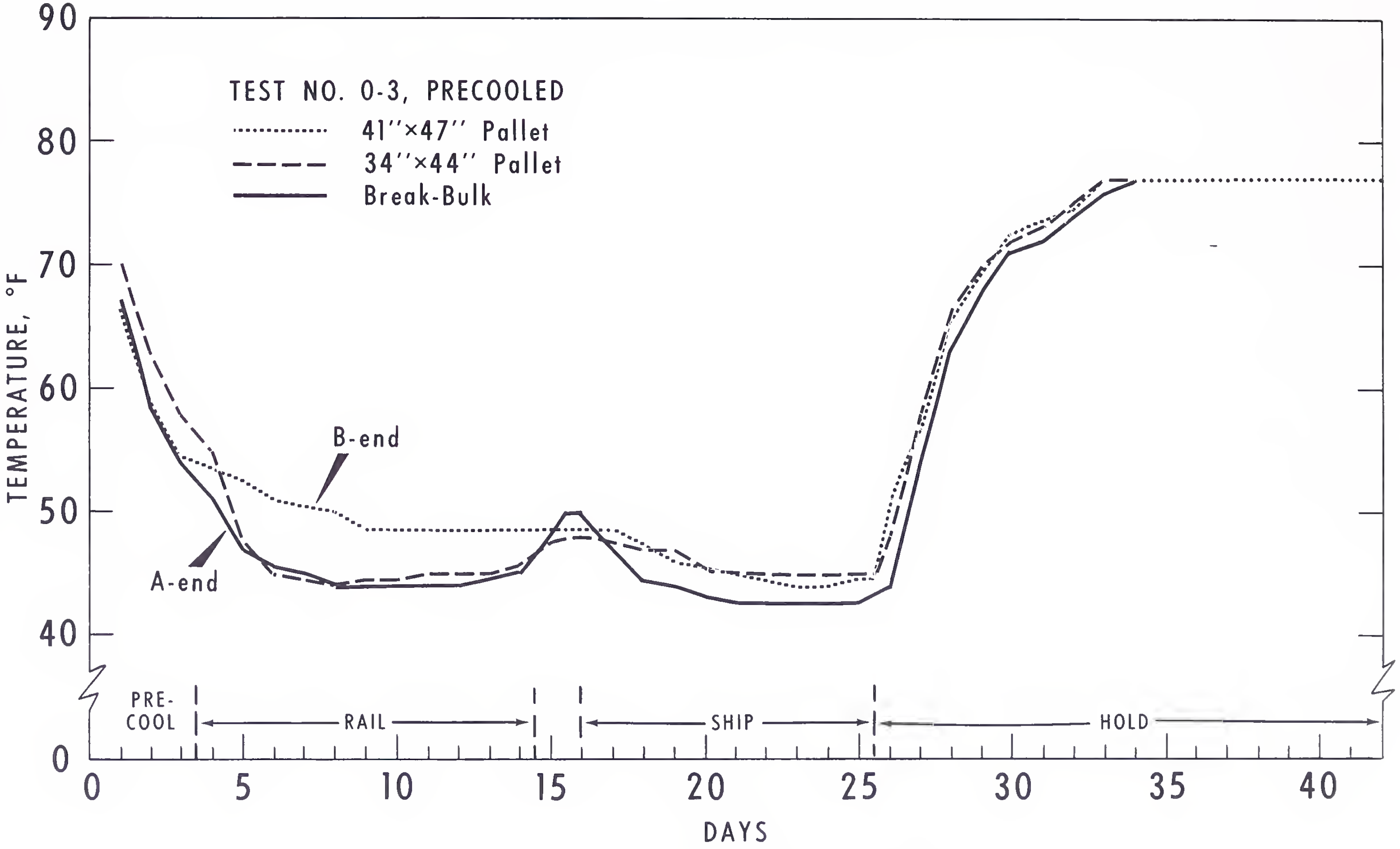
PACKED 5/20/68; LOADED 5/20/68; UNLOADED 6/11/68.

*Figure 2.*—Transit and holding temperatures of oranges shipped to Rotterdam break-bulk and on 34- by 34-inch and 41- by 47-inch pallets on May 20, 1968.



PACKED 5/24/68; LOADED 5/27/68; UNLOADED 6/17/68.

*Figure 3.*–Precooling, transit, and holding temperatures of oranges shipped to Rotterdam break-bulk and on 34- by 34-inch and 41- by 47-inch pallets on May 27, 1968.



PACKED 5/31/68; LOADED 6/3/68; UNLOADED 6/25/68.

*Figure 4.*–Precooling, transit, and holding temperatures of oranges shipped to Rotterdam break-bulk and on 34- by 34-inch and 41- by 47-inch pallets on June 3, 1968.

## Biphenyl Absorbed by Oranges

Effect of palletizing.—Palletizing did not consistently affect the amount of biphenyl absorbed by the oranges, although the values on arrival and 1 week after arrival tended to be higher in the palletized fruit. These results appear in tables 1 and 2.

Effect of precooling.—Cooling of oranges in the precooling rooms was slow and irregular. It had no noticeable effect on the amount of biphenyl absorbed.

TABLE 1.—*Effect of palletizing on biphenyl residue in oranges on arrival in Holland and 1 and 2 weeks after arrival—1968*

| Holding period by pallet type | Biphenyl more than— | | | |
|---|---|---|---|---|
| | 70 ppm. | 80 ppm. | 100 ppm. | 110 ppm. |
| | *Percent* | | | |
| On arrival: | | | | |
| Break-bulk | 0 | 0 | 0 | 0 |
| 34" x 34" pallet | 8 | 0 | 0 | 0 |
| 41" x 47" pallet | 0 | 0 | 0 | 0 |
| 1 week after arrival[1] | | | | |
| Break-bulk | 25 | 8 | 0 | 0 |
| 34" x 34" pallet | 75 | 17 | 0 | 0 |
| 41" x 47" pallet | 58 | 18 | 0 | 0 |
| 2 weeks after arrival[1] | | | | |
| Break-bulk | 83 | 56 | 27 | 0 |
| 34" x 34" pallet | 75 | 58 | 25 | 17 |
| 41" x 47" pallet | 83 | 58 | 0 | 0 |

[1] Holding was at ambient temperature of 70.5° to 79° F.

TABLE 2.—*Effect of palletizing on biphenyl residue, decay, and soilage in oranges on arrival in Holland and 1 and 2 weeks after arrival—1968*

| Biphenyl, decay, and soilage by pallet type | On arrival | 1 week after arrival[1] | 2 weeks after arrival[1] |
|---|---|---|---|
| Biphenyl (parts per million): | | | |
| Break-bulk | 44 | 66 | 87 |
| 34" x 34" pallet | 49 | 75 | 86 |
| 41" x 47" pallet | 43 | 73 | 83 |
| Average | 45 | 71 | 85 |
| Decay (percent): | | | |
| Break-bulk | 1.4 | 5.2 | 9.9 |
| 34" x 34" pallet | 1.5 | 6.5 | 7.0 |
| 41" x 47" pallet | 1.7 | 3.4 | 7.1 |
| Average | 1.5 | 5.0 | 8.0 |
| Soilage (percent): | | | |
| Break-bulk | 0.8 | 5.9 | 17.0 |
| 34" x 34" pallet | 2.2 | 6.4 | 14.2 |
| 41" x 47" pallet | 2.3 | 4.6 | 11.0 |
| Average | 1.8 | 5.6 | 14.1 |

[1] Holding was at ambient temperature of 70.5° to 79° F.

The fruit loaded directly into the cars cooled almost as rapidly as fruit placed in the precooling rooms. In addition, the precooled fruit had been packed and exposed to biphenyl 3 days longer than the nonprecooled fruit had on arrival at Rotterdam. Table 3 shows the similarity of the biphenyl content of precooled and nonprecooled oranges.

Effect of holding in Holland.—Nearly all the biphenyl values were below 70 p.p.m. at the first examination after arrival at Rotterdam. More than one-half of the samples analyzed 1 week after arrival exceeded 70 p.p.m. and from 75 to 90 percent of the samples analyzed 2 weeks after arrival exceeded this value. Only a few samples contained more than 100 p.p.m., even after 2 weeks at the relatively high ambient temperature of 70.5° to 79.0° F. The highest value on arrival was 72 p.p.m., 1 week after arrival, 90 p.p.m., and 2 weeks after arrival, 120 p.p.m.

Effect of pad placement.—Two pad placements, middle and bottom, and between layers, produced the highest biphenyl residue in the oranges (table 4). The lower biphenyl residue in fruit in cartons with the pads at the top and bottom agrees with previously reported data. [3] The lowest residue values were found in fruit from cartons with one pad at the middle. Reduction in biphenyl residue by this method was often accompanied by increased decay and soilage, especially after 1 and 2 weeks' holding. Top and bottom placement of pads may be the most acceptable choice, as it gives a moderate reduction in residue without excessive sacrifice in the control of decay and soilage.

Condition of Oranges

Effect of palletizing.—Although palletizing did not consistently influence biphenyl residue, it may have reduced decay and soilage. The average decay and soilage values for nonpalletized fruit were slightly lower than for palletized fruit on arrival, but were considerably higher at the end of the holding period (table 2). The percentage of decayed fruit increased sevenfold in nonpalletized fruit, fivefold in fruit on the small pallets, and fourfold in fruit on the large pallets during the 2-week holding period. The respective increases in soilage were 21-fold, sixfold, and fivefold. The greater increase in decay and soilage of nonpalletized fruit may have resulted from increased injury associated with the difference in handling procedures.

Effect of precooling.—The data in table 3 show that precooling did not reduce either decay or soilage. The values for the nonprecooled fruit in test No. 0-1 and the precooled fruit in test No. 0-2 are nearly alike. The higher decay and soilage values in the precooled fruit in test No. 0-3 compared with the values in tests 0-1 and 0-2 are probably attributable to the poorer inherent quality of the fruit in test No. 0-3. The average transit temperatures of tests 0-1, 0-2, and 0-3 (including precooling where applicable), were 48.6, 46.0, and 48.7° F., respectively.

TABLE 3.—*Effect of precooling on biphenyl residue, decay, and soilage in oranges on arrival in Holland and 1 and 2 weeks after arrival—1968*

[Test No. 0-1 not precooled; No. 0-2 and No. 0-3 precooled 3 days.]

| Biphenyl, decay, and soilage by test number | On arrival | 1 week after arrival[1] | 2 weeks after arrival[1] | Average |
|---|---|---|---|---|
| Biphenyl (parts per million): | | | | |
| Test No. 0-1 . . . . . . . . . . | 42 | 74 | 90 | 69 |
| Test No. 0-2 . . . . . . . . . . | 51 | 71 | 86 | 69 |
| Test No. 0-3 . . . . . . . . . . | 46 | 71 | 86 | 68 |
| Decay (percent): | | | | |
| Test No. 0-1 . . . . . . . . . . | 0.6 | 3.7 | 5.4 | 3.1 |
| Test No. 0-2 . . . . . . . . . . | .8 | 4.8 | 5.1 | 3.6 |
| Test No. 0-3 . . . . . . . . . . | 3.1 | 6.6 | 13.5 | 7.7 |
| Soilage (percent): | | | | |
| Test No. 0-1 . . . . . . . . . . | 0.6 | 3.9 | 12.5 | 5.7 |
| Test No. 0-2 . . . . . . . . . . | .3 | 4.1 | 11.5 | 5.3 |
| Test No. 0-3 . . . . . . . . . . | 4.5 | 8.9 | 18.3 | 10.5 |

[1] Holding was at ambient temperature of 70.5° to 79° F.

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[3] *Norman, S., Rygg, G. L.,* and *Fouse, D. C. Biphenyl Residues in Oranges: Effect of Biphenyl Dosage and pad placement.* U. S. Dept. Agr. ARS 51-26, 8 pp. 1968.

Effect of holding in Holland.—Decay and soilage increased threefold to fourfold during 1 week's holding after arrival. Decay incidence after 2 weeks' holding was four to 10 times its value on arrival, and soilage was eight to 16 times its value on arrival (table 4). The rapid deterioration after arrival emphasizes the importance of refrigeration during distribution and marketing.

Effect of pad placement.—No one pad placement had given outstandingly superior results on arrival. Placement of pads between layers was the most effective for reducing decay and soilage after 2 weeks' holding. Top and bottom placement and middle and bottom placement were about equally effective after 2 weeks. One pad at the middle of the carton was the least effective placement for controlling decay and soilage, but this gave the lowest biphenyl residue (table 4). Top and bottom placement resulted in the lowest residue without excessive sacrifice in control of decay and soilage.

### Biphenyl Remaining in Pads

Fifty-eight to 65 percent of the applied biphenyl remained in the pads at the time of the first examination in Holland, assuming that each pad contained 2,140 milligrams biphenyl at the beginning of the test. About one-half of the biphenyl present on arrival was lost from the pads during the first week of holding, and about one-half of the remainder escaped during the second week. The rates of loss associated with the various placements were quite similar, but the rate in cartons with the pads at the top and bottom was consistently slightly higher than the rate associated with the other placements. Previous tests have shown that pads on top of the fruit lose biphenyl more rapidly than those placed lower in the carton.[4,5] Table 4 gives the amount of biphenyl remaining in the pads in milligrams per pad at each examination.

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[4] Rygg, G. L., Wells, A. W., Norman, S. M., and Atrops, E. P. *Biphenyl Control of Lemon Spoilage—Influence of Time, Temperature, and Carton Venting.* U. S. Dept. Agr. Mktg. Res. Rpt. 569, 15 pp. 1962.

[5] Rygg, G. L., Wells, A. W., Norman, S. M., and Atrops, E. P. *Biphenyl Control of Citrus Spoilage—Influence of Time, Temperature, and Carton Venting.* U. S. Dept. Agr. Mktg. Res. Rpt. 646, 22 pp. 1964.

TABLE 4.—*Effect of pad placement on biphenyl content of oranges and pads and on decay and soilage in oranges on arrival in Holland and 1 and 2 weeks after arrival—1968*

| Biphenyl, decay, and soilage by pad placement | On arrival | 1 week after arrival[1] | 2 weeks after arrival[1] | Average |
|---|---|---|---|---|
| Biphenyl in fruit (parts per million): | | | | |
| Top and bottom . . . . . . | 44 | 68 | 85 | 66 |
| Middle and bottom . . . . | 48 | 78 | 94 | 73 |
| Between layers . . . . . . | 49 | 79 | 93 | 74 |
| Middle only . . . . . . . . | 39 | 59 | 68 | 55 |
| Biphenyl per pad (milligrams): | | | | |
| Top and bottom . . . . . . | 1,246 | 524 | 214 | 661 |
| Middle and bottom . . . . | 1,385 | 656 | 333 | 791 |
| Between layers . . . . . . | 1,345 | 749 | 429 | 841 |
| Middle only . . . . . . . . | 1,346 | 618 | 302 | 755 |
| Decay (percent): | | | | |
| Top and bottom . . . . . . | 1.3 | 3.5 | 7.2 | 4.0 |
| Middle and bottom . . . . | 1.7 | 5.0 | 7.1 | 4.6 |
| Between layers . . . . . . | 1.2 | 4.4 | 5.2 | 3.6 |
| Middle only . . . . . . . . | 1.3 | 7.5 | 12.9 | 7.2 |
| Soilage (percent): | | | | |
| Top and bottom . . . . . . | 1.0 | 4.1 | 16.1 | 7.1 |
| Middle and bottom . . . . | 1.8 | 5.0 | 13.9 | 6.9 |
| Between layers . . . . . . | .9 | 5.6 | 7.5 | 4.5 |
| Middle only . . . . . . . . | 2.4 | 8.9 | 20.9 | 10.7 |

[1] Holding was at ambient temperature of 70.5° to 79° F.

## Lemons

### Temperatures

Acceptable temperatures were maintained in both containers during the transit period. The temperature of the palletized load (L-2) attained 60° F. during the third day and dropped to 55° by the end of the ninth day. It remained in the middle 50°s until the load arrived at the destination (fig. 5). The average transit temperature of the break-bulk load (L-1) was 57.1° and that of the palletized load 57.5° . The cooling rates of the two loads were similar.

The temperatures shown in figure 5 were recorded in cartons one-fourth the distance from the door at the end of the container to the end with the cooling unit. The recorded transit temperature at the forward quarterlength was usually at least 3 degrees lower than the temperature at the rear quarterlength (toward the door). This difference is similar to the one observed in the orange test shipment in mechanically refrigerated railcars (page 6).

The average transit temperature of the air above the load in the container with the break-bulk load (L-1) was 51.2° F., and that in the container with the pallet load (L-2) was 51.8° .

### Biphenyl Absorbed by Lemons

Lemons in the break-bulk load contained 20 p.p.m. biphenyl, and those in the palletized load 18 p.p.m. on arrival. After 2 weeks' nonrefrigerated holding, the biphenyl in the two lots of lemons had equalized at 25 p.p.m. (table 5). The biphenyl residue values on arrival were lower than those of seven of the nine test shipments analyzed in 1967.[6] The low residues may be the result of the fairly uniform and adequately cool transit temperatures maintained in the cargo containers.

### Condition of Lemons

Decay and soilage in the test lemons varied, and the condition was not consistently related to the treatments. Decay, and to a lesser extent soilage, increased more rapidly in break-bulk fruit than in palletized fruit during the 2 weeks' holding in Holland. Similar results had been observed in oranges (page 11). The values for lemons appear in table 5.

### Biphenyl Remaining in Pads

The pads in lemon cartons lost biphenyl at about the same average rate as those in orange cartons. Biphenyl remaining in the pads in the lemon cartons on arrival amounted to 47 to 65 percent of the estimated initial content. About one-fourth of the amount present on arrival remained after 2 weeks' storage. Table 5 gives the amount of biphenyl remaining in milligrams per pad at each inspection.

## Suitability of Pallets and Containers for Citrus Transportation

Palletization has a potential of considerable usefulness in the handling of produce in applicable situations. Properly used, it can reduce labor requirements, reduce injury to produce from rough handling, expedite loading and unloading, and facilitate movement in the trade channels. To enable the receivers to secure maximum benefits from palletization, each pallet should contain only one size and brand of a given kind of produce unless especially requested. The size and brand should be readily discernible on each side of the pallet load, and the cartons in at least one vertical column on each side of the pallet should be clearly marked with this information. These practices often enable the receiver to distribute the produce to his customers in intact pallet loads. Time and labor will be saved, and the reduced moving of the produce by hand will reduce damage.

The pallets need stronger boards, especially at the sides, than the brittle and rather knotty ones used in the tests reported here. The pallet size must be coordinated carefully with the size of the cartons in the load. The cartons must not be allowed to extend beyond the pallet. On the other hand, if the pallet is too large the cartons will shift because the pallet will limit the tightness of the load. The pallets should be designed to permit four-way pickup.

The taping and binding of the pallet loads were fairly satisfactory on the small pallets, but several of the loads on the large pallets shifted excessively in transit or fell apart during handling. The boards in the large pallets frequently broke in handling.

Shipping citrus fruits on pallets does not appear to increase biphenyl residue as compared with shipping break-bulk.

A direct comparison of shipping citrus fruit in cargo containers with handling of fruit in the customary commercial manner was not possible in these tests.

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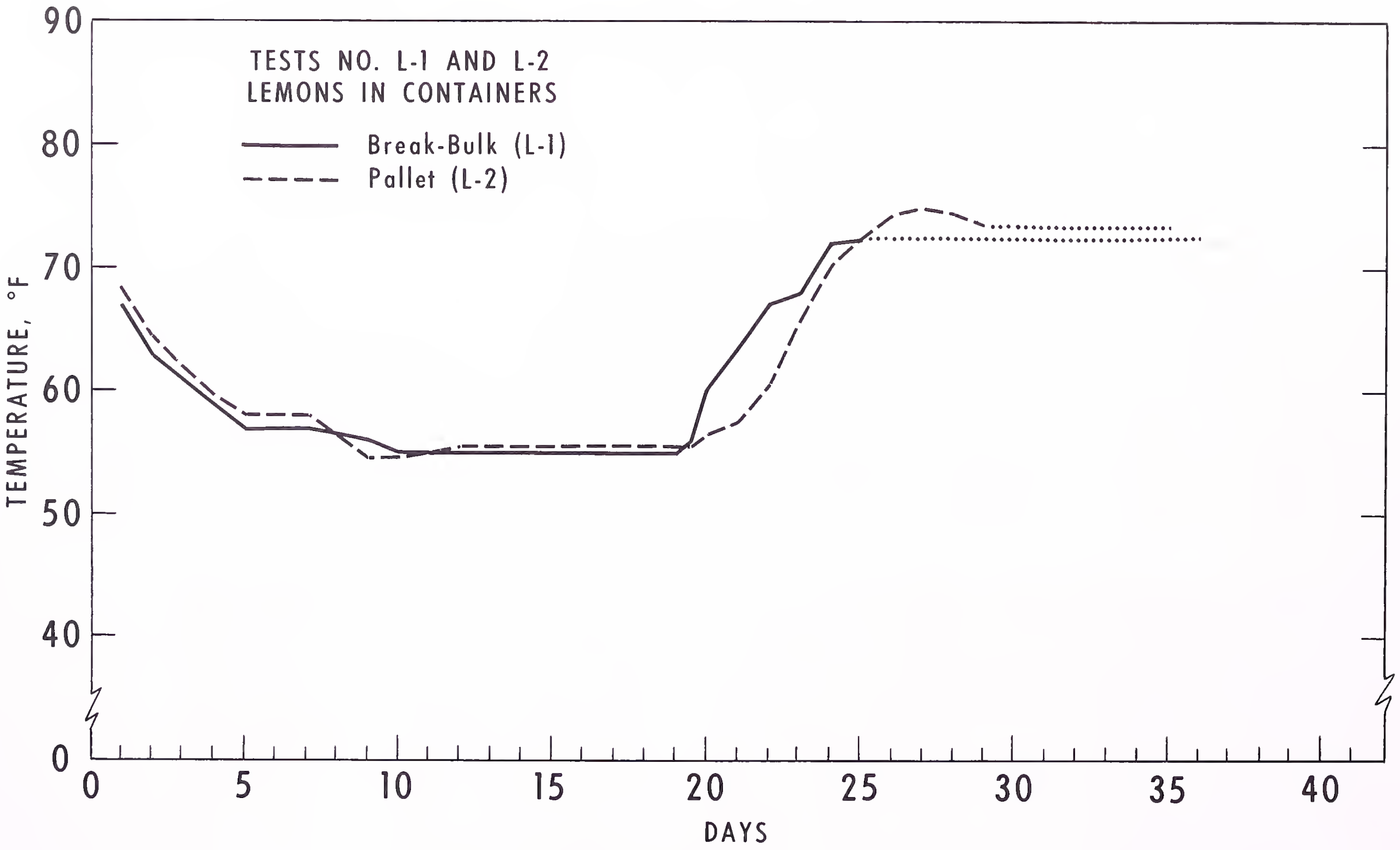
[6] See footnote 2.



PACKED AND LOADED 7/15/68; UNLOADED 8/2/68.

*Figure 5.*—Transit and holding temperatures of lemons shipped to Rotterdam break-bulk and on 35- by 42-inch pallets in cargo containers on July 15, 1968.

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TABLE 5.—*Effect of palletizing on biphenyl content of lemons and pads and on decay and soilage in lemons on arrival in Holland and 1 and 2 weeks after arrival—1968*

| Biphenyl, decay, and soilage by type of load | On arrival | 1 week after arrival[1] | 2 weeks after arrival[1] |
|---|---|---|---|
| Biphenyl in lemons (parts per million): | | | |
| Break-bulk load . . . . . | 20 | 23 | 25 |
| Pallet load . . . . . . . . | 18 | [2] 19 | 25 |
| Bipheyl per pad (milligrams): | | | |
| Break-bulk load . . . . . | 1,400 | 580 | 380 |
| Pallet load. . . . . . . . | 1,000 | [2] 1,180 | 260 |
| Decay (percent): | | | |
| Break-bulk load . . . . . | 2.4 | 1.5 | 12.7 |
| Pallet load . . . . . . . . | 3.6 | [2] 3.0 | 4.3 |
| Soilage (percent): | | | |
| Break-bulk load . . . . . | 1.9 | 2.4 | 4.4 |
| Pallet load. . . . . . . . | 3.0 | 9.0 | .7 |

[1] Holding was at ambient temperature of 72° to 75° F.
[2] Carton contained one bottom pad only.

Tentative comparisons may be made, however, between the results of these tests and the lemon tests conducted in 1967.[7] Average biphenyl residue, decay, and soilage were lower in containerized fruit in 1968 than in comparable fruit shipped break-bulk in 1967.

Although comparable data are not available for oranges, the results suggest that the biphenyl residue in fruit shipped in containers is not likely to be higher than the residue in fruit handled in the customary manner, but might be somewhat lower. To minimize rough handling and expedite fruit movement, a combination of pallets and containers should be advantageous.

Economic feasibility and availability of all the necessary equipment will govern the adoption of pallets and containers, even though they may favorably affect the arrival quality of the fruit.

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[7] See footnote 2.

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